

The Effect of Activated Carbon Injection on Arsenic, Cadmium, Lead and Selenium in Fly Ash

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DOE/NETL Mercury Control Technology R&D
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Overview

- Full-scale evaluations of activated carbon injection (ACI) on coal-fired boilers (up to 150 MW equivalent)
- Effect of ACI on byproducts:
 - LOI, surface area
 - Leaching of Hg
 - Impact on other trace metals?
- Measure trace metals (As, Cd, Pb, Se) in fly ash with and without ACI



ADA-ES Phase I Program

- DOE-sponsored full-scale field testing of sorbent-based mercury control on non-scrubbed coal-fired boilers
- Co-funding provided by:
 - Southern Company
 - WE Energies
 - PG&E NEG
 - EPRI
 - Ontario Power Generation
 - First Energy
 - TVA
 - Kennecott Energy

Phase I Test Sites

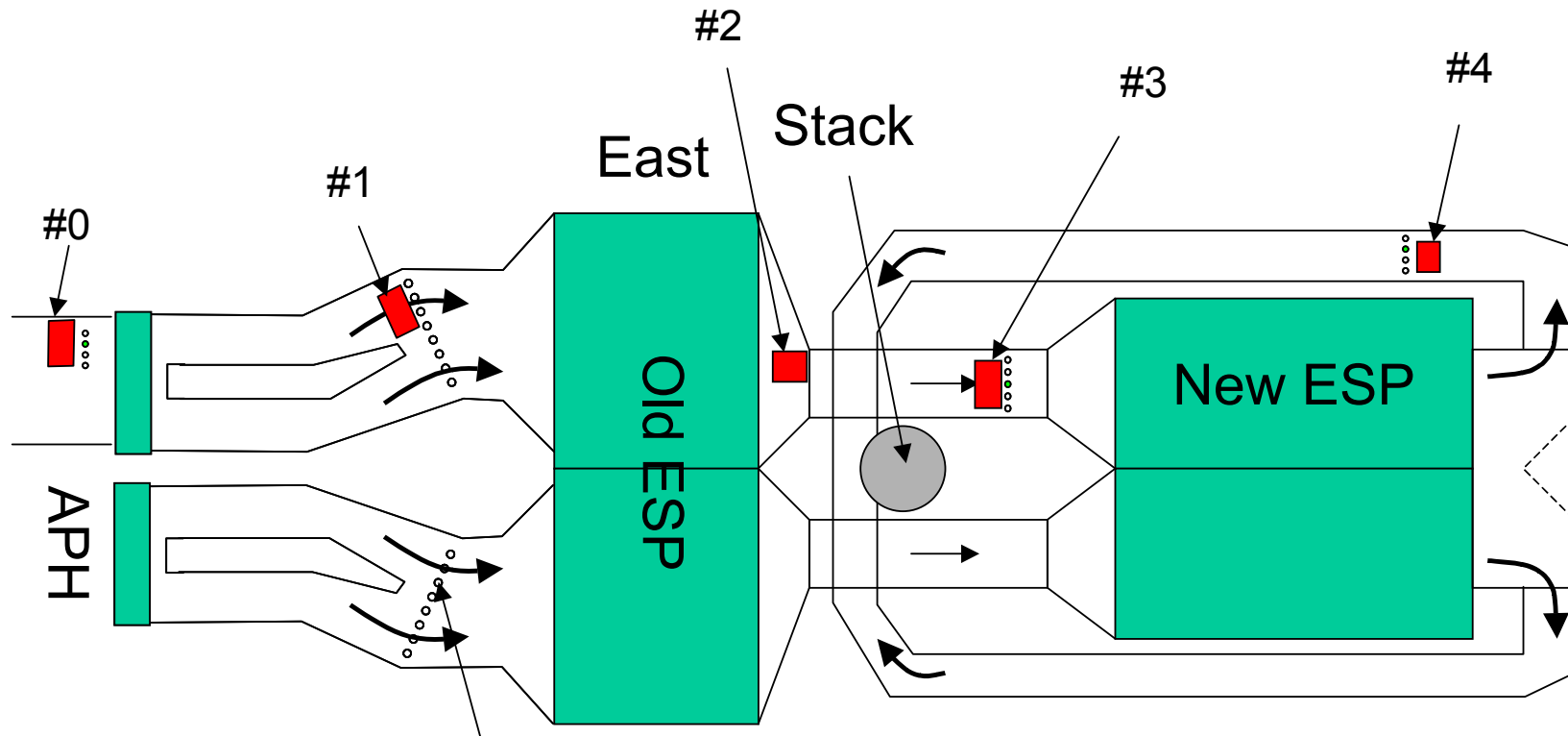
Test Site	Coal	Particulate Control
PG&E NEG Brayton Point	Bituminous	CS ESP
PG&E NEG Salem Harbor	Bituminous	CS ESP
Alabama Power Gaston	Bituminous	HS ESP/ COHPAC FF
WE Energies Pleasant Prairie	PRB	CS ESP



Brayton Point Site Description

- PG&E National Energy Group plant, located in Somerset, Massachusetts
- 3 coal-fired units and one oil/gas
- Test unit (Unit 1) has a tangentially fired boiler rated at 245 MW_{net}
- Particulate control: two cold-side ESP's in series
 - Old ESP has SCA of 156 ft²/1000 acfm
 - New ESP has SCA of 403 ft²/1000 acfm
- ESP inlet gas temperature 280°F at full load.

ESP Configuration - Brayton



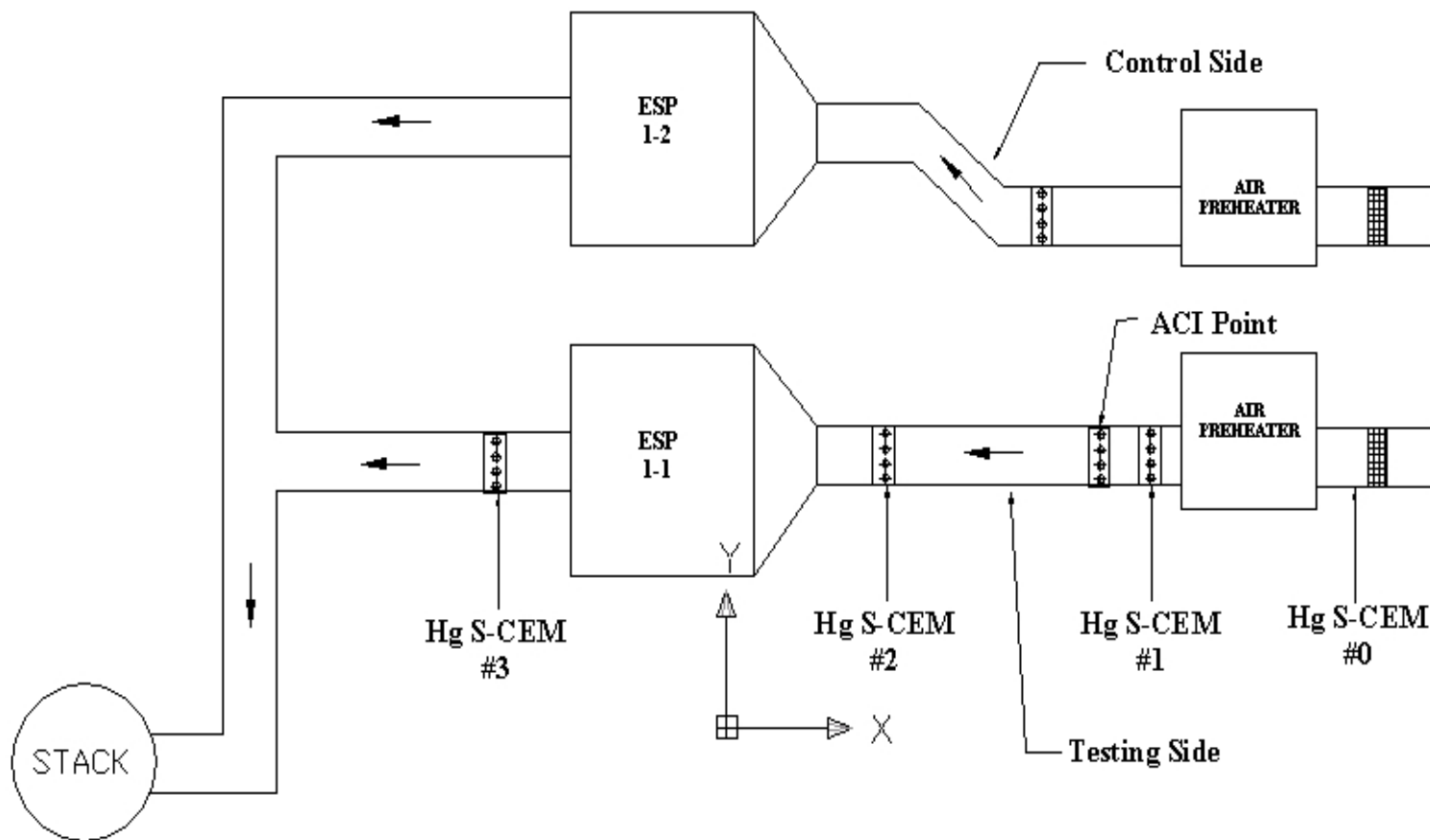
- Sorbent injected between Old and New ESPs



Salem Harbor Site Description

- PG&E National Energy Group's Salem Harbor Station, located in Salem, Massachusetts
- Test unit (Unit 1), 80 MW, B&W single-wall-fired furnace
- Low-sulfur bituminous coal
- SNCR system
- Two-chamber, cold-side ESP, SCA of 474 ft²/1000 acfm
- ESP inlet gas temperature, nominally 255°F at full load

ESP Configuration – Salem Harbor





Solid Samples

- Coal feeder samples and ash hopper samples taken periodically
- Virgin activated carbon sampled
- Coal analysis (Microbeam Technologies)
 - Standard (ult/prox/ash)
 - Hg and Cl content
- Ash analysis (Microbeam Technologies)
 - LOI
 - Hg, As, Cd, Pb, Se content
 - Special tests as required (Surface area, PSD, leaching)

Fuel Characteristics

	Brayton Point	Salem Harbor
As received:		
Carbon	72.0	72.2
Hydrogen	4.5	4.6
Oxygen	5.3	7.8
Nitrogen	1.4	1.4
Sulfur	0.6	0.6
Ash	11.8	4.5
Moisture	4.4	9.0
HHV, Btu/lb	12,775	12,656
Dry values:		
Cl, ug/g	1,780	285
Hg, ug/g	0.044	0.061
As, ug/g	5.68	1.70
Cd, ug/g	0.055	0.120
Pb, ug/g	8.90	4.77
Se, ug/g	3.00	5.20



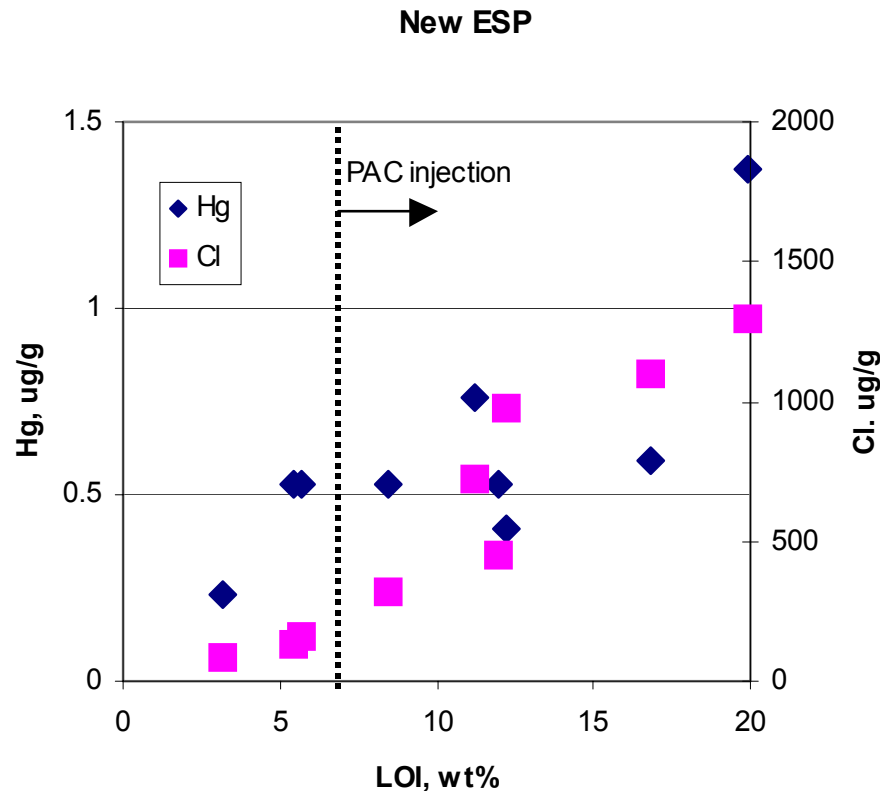
Powdered Activated Carbon Injection

- All plants used same sorbent
- Commercial sorbent (Norit Americas FGD Carbon):
 - **600 m²/g, 18 microns MMD**
- Injection rate determined by configuration:
 - **ESP: 5-20 lb/MMacf**

FGD Carbon Composition

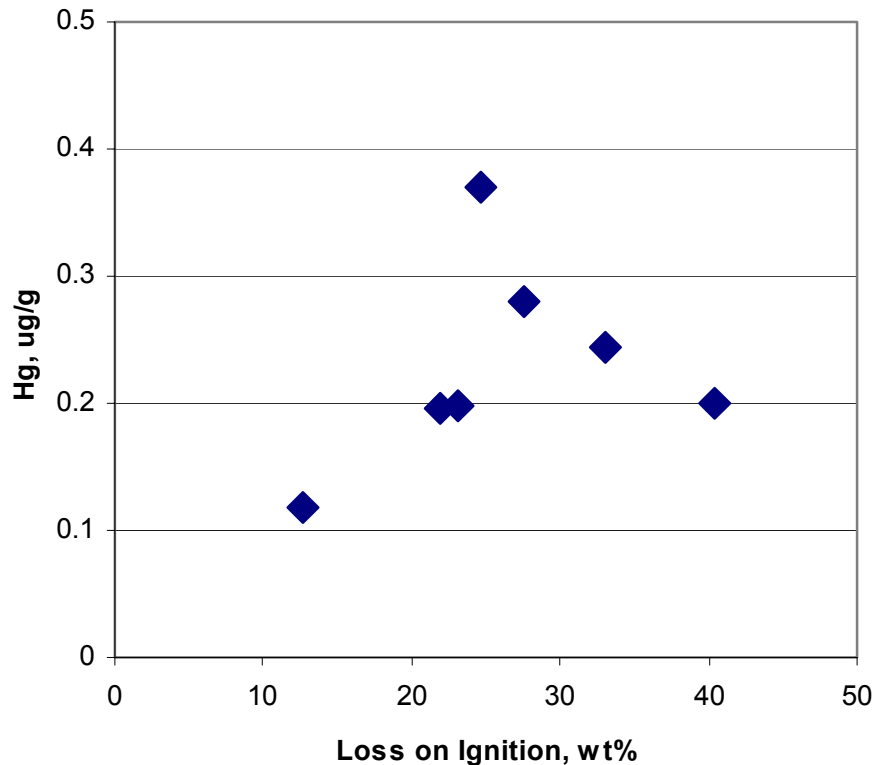
Sample ID	FGD01-86502	FGD02-Bulk	FGD03-Bulk#2	
MTI #	03-324	03-325	03-326	Average
Percent ash	31.82	33.32	31.10	32.08
Trace elements (ug/g):				
As	10	5	7.6	7.5
Cd	<0.03	<0.03	<0.03	0.02
Pb	4.3	5.1	3.8	4.4
Se	14	17	19	16.7

Brayton Point Ash Characteristics



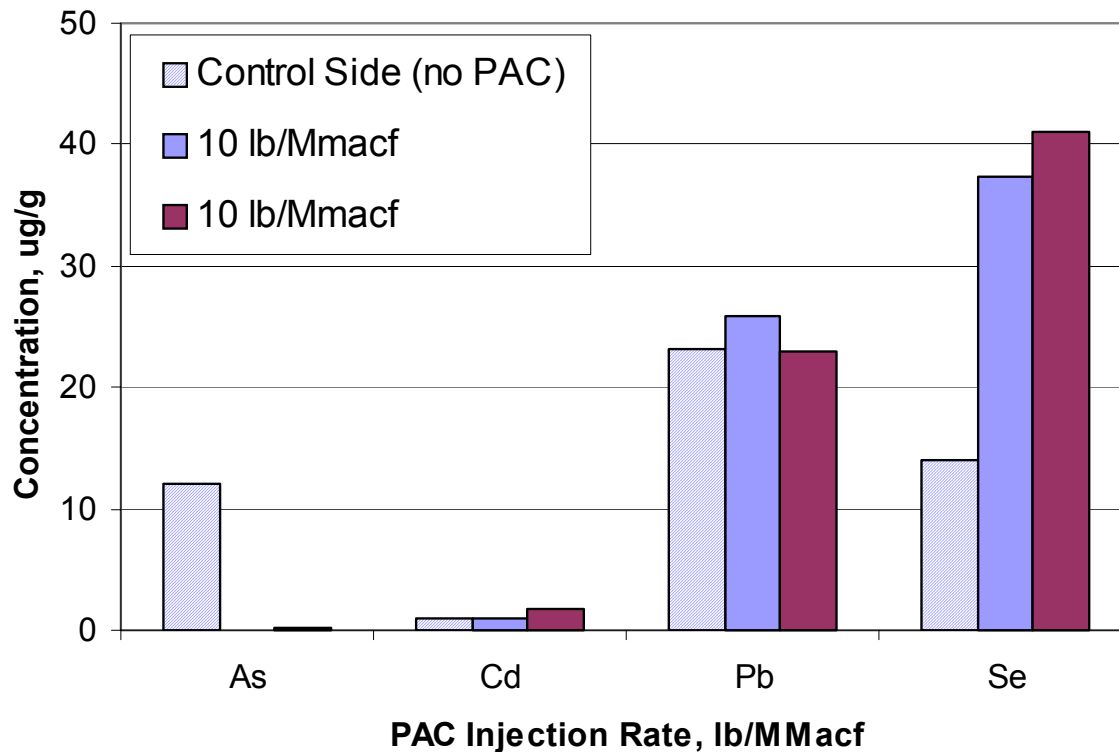
- PAC injected upstream of New ESP
- Hg-, Cl- contents increase with increasing LOI (sorbent or unburned carbon)

Salem Harbor Ash Characteristics



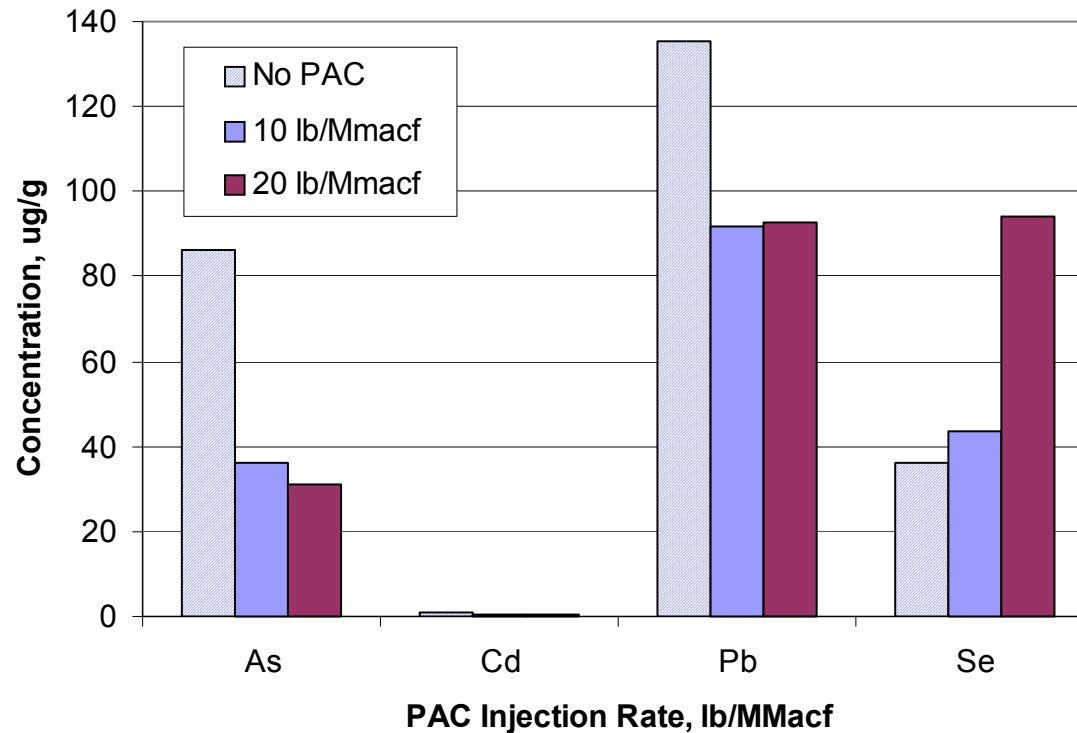
- Ash data with and without sorbent injection
- Native LOI high
- Hg-content increases with LOI up to ~20% LOI

Effect of ACI Injection: Salem Harbor



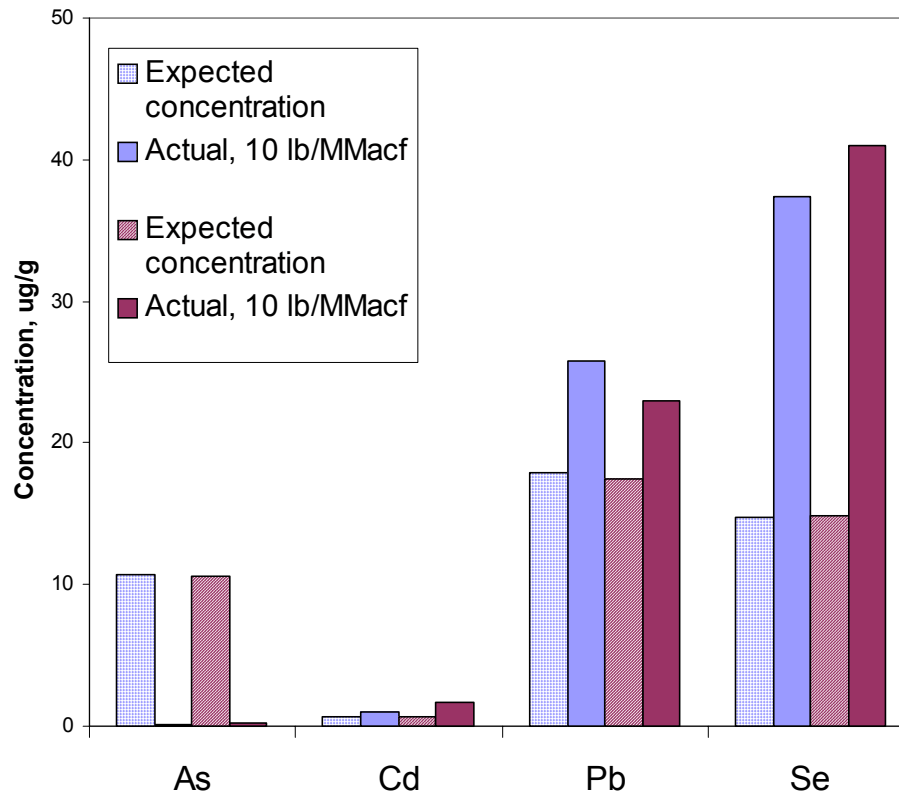
- Decrease in As concentration
- No change in Cd, Pb concentration
- Increase in Se concentration with ACI

Effect of ACI Injection: Brayton Point



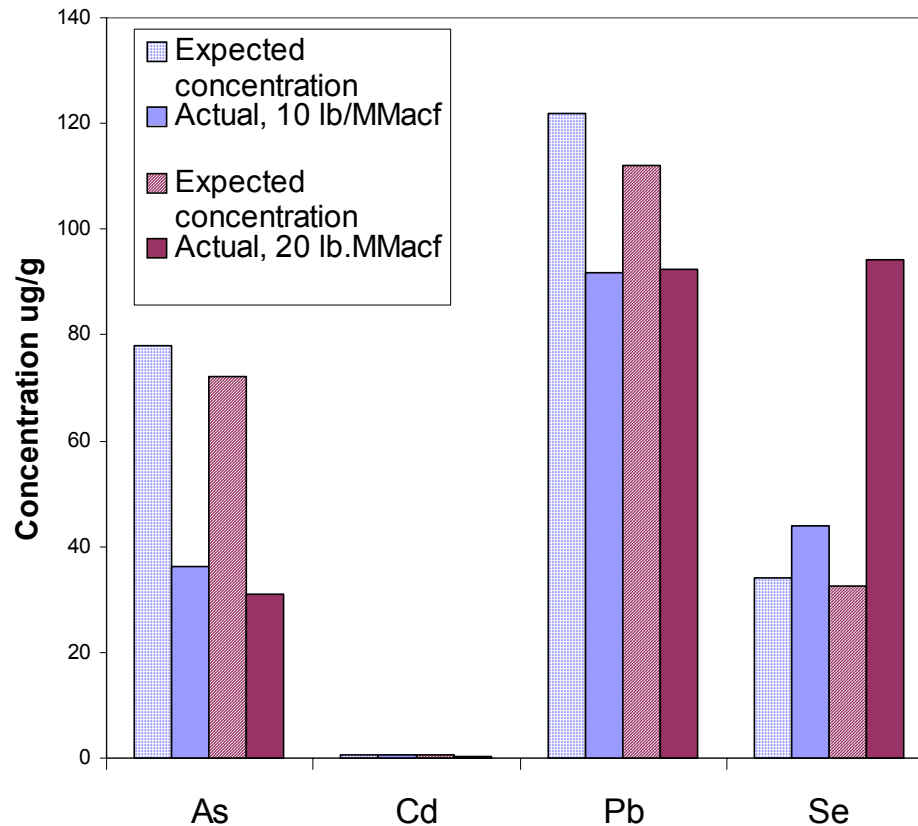
- Decrease in As, Cd, Pb concentration
- Increase in Se concentration with ACI

Effect of ACl Injection: Salem Harbor



- Calculate expected concentration of ash-FGD mixtures from ash content of FGD carbon and LOI of ash with and without FGD
- Actual concentration 2-3 times than expected for Se
- Smaller increases for Cd, Pb
- Less As than expected

Effect of ACI Injection: Brayton Point

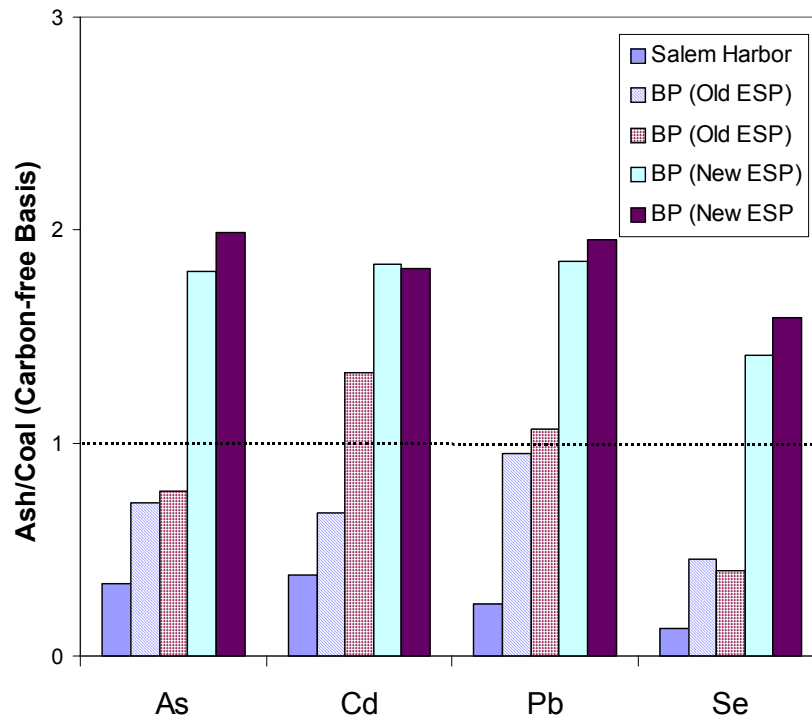


- Se concentration increases with increasing injection rate
 - Expected concentration takes into account Se in FGD carbon
 - Increase in Se above expected
- Concentrations of other trace metals lower than expected

Summary

- Trace metals (As, Cd, Pb, Se) measured in coal, ash and FGD carbon samples
- Activated carbon injection resulted in 2-3 times more Se in fly ash (10-20 lb/MMacf injection rate)
- As, Cd, Pd did not consistently increase in fly ash as a result of ACI

Enrichment in Ash: Baseline (No ACI)



$$\left(\frac{\text{Concentration in ash (carbon-free)}}{\text{Concentration in coal}} \right)$$

- Salem Harbor:
 - Ash depleted in all four trace elements with respect to coal
- Brayton Point:
 - Old ESP ash depleted in As and Se with respect to coal
 - New ESP ash enriched in all four trace elements with respect to coal
 - New ESP collected different ash particles than the old ESP